July 24, 1928. 1,678,073

J. T. PHIPPS

WELL APPARATUS

Filed Oct. 10, 1925

Fig. 1.

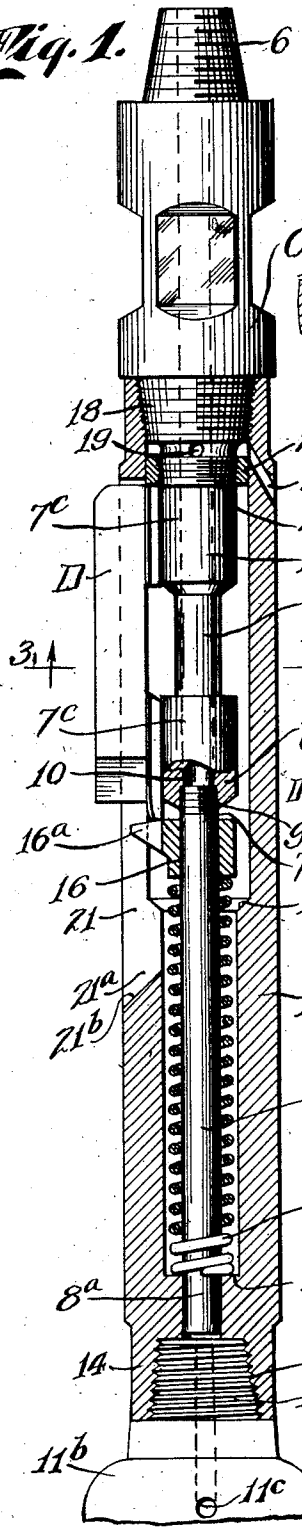


Fig. 2.

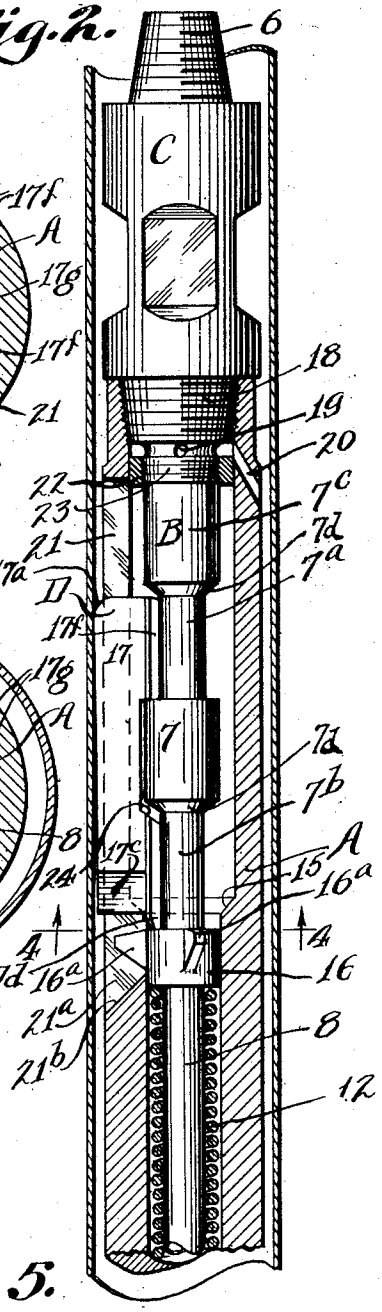


Fig. 3.

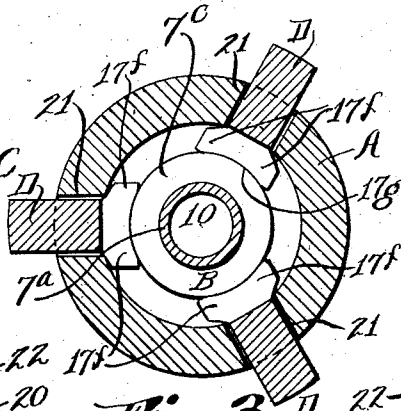


Fig. 4.

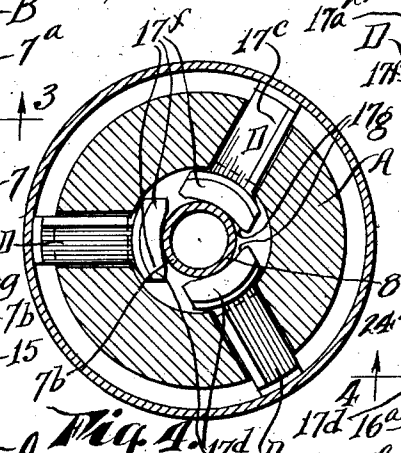
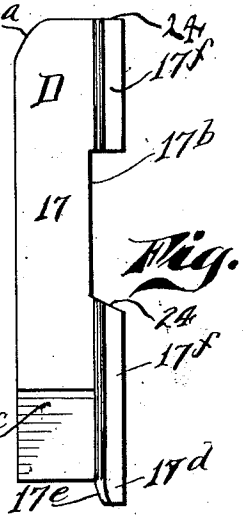


Fig. 5.



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Patented July 24, 1928. 1,678,073

UNITED STATES PATENT OFFICE.

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WELL APPARATUS.

Application filed October 10, 1925. Serial No. 61,808.

This invention relates to well apparatus, and more particularly to underreamers such as are used to enlarge the well hole in drilling operations to permit the lowering of the casing. The present invention relates to an underreamer which may be employed either in standard or cable practice, in which a reciprocating bit is used, on the one hand, or in rotary practice in which a rotating bit is used, on the other hand. Formerly there was more or less of a clear distinction between the two practices, holes being drilled by either the standard or rotary method. In modern practice both methods are frequently used in a given hole, the standard method being employed upon entering the sands, so that the same may be safely cased off and a slower drilling carried forward when approaching the producing strata. Furthermore, the standard method is employed when hard "shells" or strata are encountered, and which hard strata are extremely difficult for rotary drills to penetrate.

Therefore, in producing an underreamer adapted for service in connection with either method of hole drilling, I have provided a tool of general utility in a rig under all of the conditions which are encountered, so that the present invention may be said to provide a general utility underreamer, obviating the necessity of providing rigs especially with underreamers designed only for use in the standard or rotary method of drilling.

Further particular objects of the invention have to do with the provision of an underreamer in which the cutters are securely maintained against "dropping" or loss, which losses have been very prevalent in general underreamer practice, often resulting in damaging the hole or at times necessitating its abandonment. Also, it is the general object of the invention to provide an improved underreamer which will be generally superior in efficiency and serviceability and in which the use of moving mandrel or spring-actuated rod for the cutters is eliminated, in which a pilot or leading body of unmutilated or round or cylindrical formation may be employed ahead of the cutters, in which the cutters may be inserted from the upper end of the reamer body, in which the cutters may be effectively retained during lowering of the underreamer to prevent digging into and mutilating the pipe and obstructing the reamer in lowering, in which effective circulation may be effected throughout the underreamer, and in which all the parts may be so combined and associated as to make for length of life, durability and general reliability and effectiveness in use and service, combined with relative inexpensiveness and simplicity in construction.

With the above and other objects in view, the invention consists in the novel and useful provision, formation, construction, combination, association and inter-relation of parts, members and features, all as hereinafter set forth, shown in the drawing, and finally pointed out in claims.

In the drawing:

Figure 1 is an axial vertical sectional view, partly in elevation, of an underreamer constructed to embody the invention, parts being broken away for clearness of illustration, one of the cutters or bits being shown in expanded position;

Figure 2 is a fragmentary sectional view similar to Figure 1 showing the bits or cutters in collapsed condition;

Figure 3 is an enlarged detail transverse sectional view taken upon the line 3—3, Figure 1, and looking in the direction of the appended arrows;

Figure 4 is a similar view taken upon the line 4—4, Fig. 2, and looking in the direction of the appended arrows; and

Figure 5 is an enlarged detail side face view of one of the bits or cutters shown in the other figures, the same being in detached position.

Corresponding parts in all the figures are designated by the same reference characters.

Referring with particularity to the drawing, A designates the tubular elongated body of the underreamer, within which is provided a fixed mandrel B, which is an elongation or downward extension of a joint member or sub C, the latter having the usual tapered and coarse-threaded pin 6 at its upper end for connection with the female member of a joint to connect the under reamer with rotary casing or with a string of tools, as the case may be in accordance with the practice to be followed.

I have shown the mandrel B as provided with an upper portion 7 integral with the sub C and a lower portion 8 which is detachable therefrom and is connected by threads therewith as at 9, such lower por-

tion 8 being tubular, and the upper portion and the sub being axially and longitudinally bored as at 10, providing with the tubular lower portion 8 a continuous circulation passage from end to end of the underreamer to feed water to the passages 11^c of bit 11^b, the lower end of the body A being shown as having a threaded socket 11 within which may be secured the threaded pin of a drilling bit, if desired, so that the operations of reaming and drilling may be carried on at the same time by a single tool. D designates in each instance a bit or cutter associated with the tubular body A and the mandrel B and adapted to be projected outwardly for operative engagement with the hole formation, or to be contracted to permit the underreamer to be raised or lowered, as shown respectively in Figures 1 and 2.

Surrounding the lower portion 8 of the mandrel B is a coiled compression spring 12 which bears at its lower end against a shoulder 13 within the tubular body, and above a counter-bore 14 within which the lower end 8^a of the mandrel portion 8 is received and centered. At a pre-determined point above this shoulder 13 the tubular body A is bored out to enlarge the chamber therein, producing an annular shoulder 15, and resting upon the spring 12 at or above said shoulder is a spider or propeller 16 having a plurality of radial arms or lugs 16^a, one for each of the bits or cutters D, three of which are shown in the drawing. The spring 12 urges the spider 16 in an upward direction within the tubular body A, at all times exerting resilient pressure upon the cutters D and tending to urge them upwardly and outwardly into expanded condition. These cutters consist each of an elongated body 17 of generally flat formation lengthwise, and each rounded off at the upper outer corner, as at 17^a and provided at the inner edge portion with a notched formation as at 17^b. The lower edge portion is tapered or reduced to produce a cutting or working edge, as at 17^c, and at the inner bottom edge portion a downwardly projecting foot or nose 17^d is provided, the same being slightly rounded at its outer side edge, as at 17^e. The inner edge portion of each body 17 is also provided at each side of the body with a laterally projecting narrow rib or flange 17^f, both above and below the notched portion 17^b. The mandrel portion 7 is reduced in diameter in two portions, as at 7^a and 7^b, directly above which such mandrel portion tapers upwardly and outwardly to the full diametrical formation, as at 7^c. These reduced portions receive the inner edge portions and ribs 17^f thereon, which constitute wings or lugs, when the cutters are in collapsed condition, and the inner faces of such inner edge portions 17^f or wings or lugs are curved in a concavity, as at 17^g, to permit a close collapsing fit of the cutters against the mandrel B.

The sub C with the attached mandrel portion 7 is detachably connected by threads, as at 18, within the upper end of the tubular body A; and immediately beneath this point the mandrel is provided with one or more drilled passages or holes 19 leading inwardly to the circulation passage 10 within the mandrel, and one or more downwardly inclined holes or passages 20 is or are drilled through the tubular body A at substantially the same zone of the reamer, so that part of the circulation fluid may pass outwardly through the holes 19, within the tubular casing A, and thence outwardly and downwardly through the holes 20, finding its way downwardly outside of the body A to cooperate with the remaining portion of the fluid which passes directly downwardly through the circulation passage 10, and out at the bottom of the tool through the socketed lower end 11 thereof.

The body A is provided with three equidistant elongated slots 21 in which are accommodated the respective cutters or bits D, the ribs 17^f on said bits being adapted to play within the bore of the body and constituting retaining means for the cutters, or means opposing out-thrust thereof. The cutters have a loose working fit within such slots, permitting them to freely traverse the slots in expansion and collapsion. These slots extend downwardly below the inwardly tapering annular shoulder 15, as shown at 21^a, and are tapered beneath said shoulders, terminating in downwardly and outwardly inclined slots 21^b. When the cutters are in expanded condition they abut at their inner top portions against a collar 22 which is threaded onto the upper portion 7 of the mandrel B, as at 23, and has a slip joint fitting within the upper portion of the bore of the body A. When the cutters are collapsed they swing inwardly at their lower end portions, so that the feet or noses 17^d ride over the downwardly and inwardly inclined shoulder 15, this action taking place due to the weight of the cutters. This retracts the lower end portions of the cutters. The rounded upper outer corners 17^a of the cutters engage with the shoe at the lower end of the casing, and the cutters are thus held stationary while the body of the underreamer is further elevated. The cutters are thus forced inwardly and the travel of the noses 17^d over the shoulder 15, as above mentioned, is produced, the cutters finally coming into the collapsed positions indicated in Figures 2 and 4. As the cutters move downwardly the wings at the inner edges including the ribs 17^f, and constituting retaining means, move downwardly over the larger portions of the mandrel portion 7, over the inclined faces 7^d, and into the annular spaces

surrounding the reduced portions 7^a and 7^b, which accommodate such cutter wings in collapsed positions. At the same time the radial arms or lugs 16^a, which, when the cutters are expanded, are positioned above the annular shoulder 15, are received in the portions 21^a of the slots 21, as shown in Fig. 2, the coil spring 12 of course being put under increase compression at the same time. As the underreamer is drawn upwardly in the casing the pressure of the outer edges of the cutters against the inner walls of the casing prevents the cutters from moving upwardly in the slots 21, and thus prevents them from expanding. When the bits have passed either above or below the casing, they of course expand, under pressure of the spring 12, the feet 17^d riding upwardly out of the body bore below the annular inclined shoulder 15, just beneath which they have been received in collapsed condition, and riding outwardly over such inclined shoulder, the expanding action being aided by the upper edges 24 of the wings or retaining means on the cutters, which cooperate with the beveled faces 7^d upon the mandrel. One or both of these faces may be beveled off or inclined, the lower one being shown so formed in Fig. 5. The retaining means or wings then ride upwardly onto the full diameter portions of the mandrel B, the cutters being then maintained in expanded condition, with the retaining means in engagement with the inner walls of the body A at the sides of the slots. The inthrust of the cutters in action is taken up by the mandrel, and any out-thrust is taken up by the body A at the sides of the slots 21. In expanding and collapsing the feet 17^d ride over the lugs 16^a, over which they freely slip, being outwardly and downwardly inclined.

It will be noted that the cutters are the only moving parts of the underreamer, the mandrel being entirely stationary, which is a clear distinction from the prior art in which, in standard practice, the cutters are connected with a spring-actuated rod or mandrel and caused to expand and collapse in the movement of such part. In the present reamer, likewise, in marked distinction from prior practice, the cutters are introduced into positions at the top of the body, being slipped into place prior to the introduction of the mandrel. The cutters are therefore positively retained in place, after the mandrel has been installed, it being impossible to lose the same, as they are confined to working zones by the mandrel and the walls of the tubular body. This constitutes a marked distinction from prior practice, where the cutters, if inadvertently freed or loosened from the spring-actuated rod, frequently become lost in the well hole, causing often excessive damage and at times abandonment of the hole.

Furthermore, the stock of the body is not diminished in thickness beneath the cutters, as is often the case in general practice, and in fact the stock is thicker beneath the shoulder 15 than it is above it, and the body retains its true cylindrical formation unimpaired in strength. The lugs or wings 16^a are slightly beveled off or inclined downwardly and outwardly to relieve the expanding and collapsing actions. It will further be noticed that the fixed mandrel accommodates the fluid circulation from one end thereof to the other, and the hole 20 in the body accommodates circulation outside of the body. When the cutters are collapsed the cutting edges and corners thereof, at 17^c are so held as not to dig into the casing, the upper reduced portion 7^a of the mandrel portion 7 being of slightly greater diameter than the lower reduced portion 7^b, so that the cutters are permitted to tilt in slightly at their lower ends. The invention also provides in the collar 22 means beneath the holes 19 for limiting the circulation outwardly through the hole or holes 20 to a point above said collar. Likewise, the cutters are entirely loose and free in the body and without any direct connection with any actuating part so that the reamer is readily assembled and taken apart, and there are no eyes in the cutters for receiving actuating means, at which eyes breakages frequently takes place in other types of cutters.

It will be noted that the mandrel B and its lower or extension portion 8 are suspended from the upper end. In case the mandrel should break at or below the point of suspension it will still be supported in operative position as the lower end of 8 reaches substantially to the upper end of the bit pin 11^a and will rest on that pin in case the mandrel breaks and tends to drop. And, as the mandrel is laterally confined by the cutters and the body, it cannot move out of operative position, even though a break occurs.

The operation and method of use of the underreamer will be plain from the foregoing description, taken in connection with the accompanying drawing.

I do not desire to be understood as limiting the invention to any of the particular details, parts and features disclosed, other than in a fair and proper interpretation of the claims hereunto appended; but desire that a full and liberal spirit of interpretation be given to the invention within such claims and the foregoing description and the drawing, it being obvious that many changes, variations and substitutions may be made in such interpretation.

Having thus disclosed my invention, I claim and desire to secure by Letters Patent:

1. An expansible underreamer comprising a slotted body, a mandrel therein having a

reduced portion intermediate its ends, and cutters; each cutter having lateral projections and a recess on its inner face intermediate its ends, said lateral projections bridging the slots in said body to limit displacement of said cutters, said mandrel constituting an abutment for said cutters to hold the cutters in expanded position and to permit collapsion, and said recess bridging the reduced portion of said mandrel when the cutters are in expanded condition.

2. An expansible underreamer comprising the combination of a slotted body, a stationary mandrel having a reduced portion intermediate its ends, cutters loosely mounted in said body and limited thereby against outward displacement through said slots; each cutter having a recess with the lower end tapered and provided with means to limit downward travel, said tapered end assisting in expansion of the cutters.

3. An expansible underreamer comprising the combination of a body, a fixed mandrel in the body, cutters in said body, each cutter having a lateral projection cooperating with said mandrel, said mandrel having a reduced portion for accommodating said lateral projection when the cutter is collapsed; there being an inclined face between said reduced portion and the larger portion of the mandrel above the reduced portion and a square shoulder at the bottom of said reduced portion and above the larger portion of the mandrel, said square shoulder limiting downward action of the cutter, the inclined face assisting expansion of said cutters.

4. An underreamer comprising a tubular body, with a longitudinally slotted wall, the wall slot being narrower than the interior diameter of the body at the slot, a cutter mounted in the slot to move longitudinally therein and also to move in and out through the slot, the cutter having a shoulder wing at its inner edge adapted to bear outwardly against the inner surface of the body wall adjacent the slot, a stationary mandrel within the body, the mandrel having a part spaced from the body wall and against which the winged edge of the cutter bears inwardly when the cutter is in its outer position, and means to move the cutter longitudinally in the body slot and longitudinally of the mandrel.

5. An underreamer comprising a cylindric tubular body with a longitudinally slotted wall, the wall slots being narrower than the interior diameter of the body, cutters mounted in the slots to move longitudinally therein and also to move in and out through the slots, the cutters having shoulder wings at their inner edges adapted to bear outwardly against the inner surface of the body wall adjacent the slots, a stationary cylindric mandrel within the body having relatively enlarged and reduced parts with which the inner edge of the cutters are adapted selectively to engage by virtue of longitudinal movement, the enlarged mandrel parts being spaced from the body wall to accommodate the cutter wings between the mandrel and wall, and means to move the cutters longitudinally.

6. An underreamer comprising a tubular body with a longitudinally slotted wall, the wall slot being narrower than the interior diameter of the body at the slot, a cutter mounted in the slot to move longitudinally therein and also to move in and out through the slot, the cutter having a shoulder wing at its inner edge adapted to bear outwardly against the inner surface of the body wall adjacent the slot, a stationary mandrel within the body, the mandrel having a part spaced from the body wall and against which the winged edge of the cutter bears inwardly when the cutter is in its outer position, and means to move the cutter longitudinally in the body slot and longitudinally of the mandrel, said means embodying a spring surrounding the mandrel and housed within the body in the space between it and the mandrel.

7. An underreamer comprising a cylindric tubular body with a longitudinally slotted wall, the wall slots being narrower than the interior diameter of the body, cutters mounted in the slots to move longitudinally therein and also to move in and out through the slots, the cutters having shoulder wings at their inner edges adapted to bear outwardly against the inner surface of the body wall adjacent the slots, a stationary cylindric mandrel within the body having relatively enlarged and reduced parts with which the inner edge of the cutters are adapted selectively to engage by virtue of longitudinal movement, the enlarged mandrel parts being spaced from the body wall to accommodate the cutter wings between the mandrel and wall, and means to move the cutters longitudinally, said means embodying a spring surrounding the mandrel and housed within the body in the space between it and the mandrel.

8. An underreamer comprising a tubular body with a slotted wall, a cutter adapted to move in and out through the wall slot, a mandrel suspended from its upper end within the body, the mandrel forming an inner abutment against which the cutter bears inwardly and the cutter and mandrel being so formed that relative longitudinal movement between them in one direction causes outward movement of the cutter, and means to cause said relative longitudinal movement including a member surrounding the said mandrel and movable longitudinally thereon.

9. An underreamer comprising a tubular body with a slotted wall, a cutter adapted to

move in and out through the wall slot, a mandrel within the body, the mandrel forming an inner abutment against which the cutter bears inwardly and the cutter and mandrel being so formed that relative longitudinal movement between them in one direction causes outward movement of the cutter, and means to cause said relative longitudinal movement including a spring surrounding the said mandrel.

10. An underreamer comprising a tubular body with a longitudinally slotted wall, a cutter adapted to move in and out through the wall slot and to move longitudinally in the wall slot, a stationary longitudinal mandrel suspended from its upper end within the body, the mandrel forming an inner abutment against which the cutter bears inwardly and the cutter and mandrel being so formed that longitudinal movement of the cutter causes its outward movement, and means to cause such longitudinal movement including a member surrounding the said mandrel and engaging the cutter.

11. An underreamer comprising a tubular body with a longitudinally slotted wall, a cutter adapted to move in and out through the wall slot and to move longitudinally in the wall slot, a stationary longitudinal mandrel within the body, the mandrel forming an inner abutment against which the cutter bears inwardly and the cutter and mandrel being so formed that longitudinal movement of the cutter causes its outward movement, and means to cause such longitudinal movement including a cutter actuating spring surrounding the said mandrel.

12. An underreamer comprising a tubular body with a slotted wall, a cutter adapted to move in and out through the wall slot, a mandrel within the body, the mandrel forming an inner abutment against which the cutter bears inwardly and the cutter and mandrel being so formed that relative longitudinal movement between them in one direction causes outward movement of the cutter, means to cause said relative longitudinal movement including a member surrounding the said mandrel, and the said mandrel having a longitudinal bore through it forming a water course.

13. An underreamer comprising a tubular body with a longitudinally slotted wall, a cutter adapted to move in and out through the wall slot and to move longitudinally in the wall slot, a stationary longitudinal mandrel within the body, the mandrel forming an inner abutment against which the cutter bears inwardly and the cutter and mandrel being so formed that longitudinal movement of the cutter causes its outward movement, and means to cause such longitudinal movement including a cutter actuating spring surrounding the said mandrel, the said mandrel being mounted at both ends in the body and having a longitudinal bore through it forming a water course.

14. In an underreamer, a tubular body having a threaded box at its lower end to connect with a drilling bit, a stationary mandrel extending longitudinally through the body, mounted in the body at its upper and lower ends, and having a water course longitudinally through it, the lower end of the water course communicating with said box, the mandrel being spaced from the body wall, cutters carried in the body surrounding the said mandrel and having inward bearings against the mandrel, and a cutter actuating spring surrounding the said mandrel within the body.

15. In an underreamer, a tubular body with a slotted wall, a longitudinal mandrel within the body and having relatively large and small parts, the surface of the larger part being spaced from the body wall and substantially parallel to it, a cutter in the wall slot having a wing fitting in the space between the wall and the large part of the mandrel, and means to cause relative longitudinal movement between the cutter and mandrel.

16. In an underreamer, a tubular body with a longitudinally slotted wall, a stationary longitudinal mandrel within the body and having relatively large and small parts, the surface of the larger part being spaced from the body wall and substantially parallel to it, a cutter movable along and in and out through the wall slot and having a wing fitting in the space between the wall and the large mandrel part, and means to move the cutter longitudinally.

17. In an underreamer, the combination of a cutter and a cutter supporting mandrel, both cutter and mandrel having two longitudinally spaced laterally projecting parts with a recess between, the cutter and mandrel being relatively movable longitudinally and the two projecting parts of the cutter engaging the two projecting parts of the mandrel in one relative position of the cutter.

18. In an underreamer, a cutter spreading mandrel having a relatively large part at one point in its length and a relatively smaller part at another point in its length, a cutter, a cutter holding body associated with the mandrel and adapted to hold the cutter back against the large part of the mandrel while allowing longitudinal movement of the cutter along the mandrel, and cutter actuating means comprising a propeller and a spring mounted around the smaller part of the said mandrel and spaced longitudinally from the larger part of the mandrel.

19. In an underreamer, a cutter spreading mandrel having a relatively large part at one point in its length and a relatively smaller part at another point in its length, a

cutter, a cutter holding body associated with the mandrel and adapted to hold the cutter back against the large part of the mandrel while allowing longitudinal movement of the cutter along the mandrel, and cutter actuating means comprising a propeller and a spring mounted around the smaller part of the said mandrel and spaced longitudinally from the larger part of the mandrel, the mandrel having a longitudinal water course through it.

20. An expansible underreamer, comprising a mandrel with two longitudinally spaced reduced portions, a cutter having two longitudinally spaced lateral projections and adapted to be moved longitudinally relatively to the mandrel, said lateral projections, in one longitudinal position of the cutter, being adapted to rest in the reduced portions of the mandrel, and in another longitudinal position to rest against the mandrel beyond opposite ends of a reduced portion.

21. An underreamer comprising an elongate abutment mandrel, cutters movable lengthwise relative to the mandrel, the cutters being spaced around the mandrel and bearing inwardly against it for support against inward stresses and the mandrel and cutters being so formed that relative longitudinal movement between them causes outward movement of the cutters, means for confining the cutters against said mandrel, and cutter actuating means including a spring surrounding the said abutment mandrel.

22. An underreamer comprising an elongate abutment mandrel, cutters movable lengthwise relative to the mandrel, the cutters being spaced around the mandrel and bearing inwardly against it for support against inward stresses and the mandrel and cutters being so formed that relative longitudinal movement between them causes outward movement of the cutters, means for confining the cutters against said mandrel, and cutter actuating means including a member surrounding the said abutment mandrel and movable lengthwise thereon.

23. In a reamer, the combination of a hollow body, a stationary mandrel suspended in fixed position in the hollow body, a downward mandrel extension extending substantially to the lower end of the body interior and adapted to support the mandrel from below in event of its suspension breaking, cutters confined by the body against the mandrel, the mandrel being confined laterally by the body and cutters.

24. In a reamer, the combination of a hollow body adapted to take a drill bit at its lower end, a drill bit with a circulation passage connected to the lower end of the hollow body, a stationary mandrel suspended in fixed position in the hollow body and having a downward extension whose end substantially rests on the drill bit, the mandrel and extension having a circulation passage vertically therethrough communicating directly with the passage of the bit, cutters confined by the body against and around the mandrel, the mandrel being confined laterally by the body and cutters, and cutters carried by the body and confined thereby laterally around and against said mandrel.

25. In a reamer, the combination of a hollow body, a stationary mandrel suspended in fixed position in the hollow body, a downward mandrel extension extending substantially to the lower end of the body interior and adapted to support the mandrel from below in event of its suspension breaking, the lower end of the mandrel being laterally confined in a lower part of the body which lower part presents an upwardly facing shoulder around the mandrel, cutters confined by the body against and around the upper part of the mandrel, said upper part being confined laterally by the body and cutters, and a cutter actuating spring surrounding the mandrel and resting upon said shoulder.

In testimony whereof, I have signed my name to this specification.

JOHN T. PHIPPS.

CERTIFICATE OF CORRECTION.

Patent No. 1,678,073. Granted July 24, 1928, to

JOHN T. PHIPPS.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 6, lines 73 to 75, claim 24, strike out the clause "and cutters carried by the body and confined thereby laterally around and against said mandrel" and insert instead "cutters confined by the body against and around the mandrel, the mandrel being confined laterally by the body and cutters."; and the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 23rd day of October, A. D. 1928.

M. J. Moore,
Acting Commissioner of Patents.

(Seal)